Customizing Games for Stroke Patients

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INTRODUCTION

Strokes are the most common cause of disability in America, and 80% of stroke survivors experience motor impairment [1]. Impairment is usually limited to one side, and can include stiffness and paralysis. In addition, some stroke victims suffer from slurred speech, aphasia, emotional difficulties, and unilateral neglect, which is the inability to process events that occur in half of the visual field.

While therapy is very useful in treating stroke, it is costly, and Americans will spend an estimated 68.9 billion on stroke related costs in 2009 [2]. Most therapy occurs in one-on-one sessions with the therapist and the stroke victim. To address motor impairments, the therapist has the patient perform a series of movement with the affected limb. The therapist may send the patient home with exercises to do, but cannot monitor the movements until the next session.

We designed computer games to address the above issues. We designed a highly configurable system to give the therapist flexibility, and used widely available input devices to reduce the cost of therapy. We also included exciting game elements to motivate the patient to complete exercises.

RELATED WORK

Games have been used to deal with a wide variety of disabilities, including strokes, epilepsy, ADHD, and behavioral issues. As computer technology and gaming devices continue to decrease in price, it becomes a great tool for addressing many issues.

Some stroke research uses games and gaming systems currently in the marketplace. The Playstation 2 [3] and the Nintendo Wii gaming system [4] were shown to be helpful for users who had already regained enough mobility to play these games. However, these games were designed for people with full body functioning, and stroke patients who have just begun treatment were unable to play [3,4]. In addition, the movements required in the game may not correspond to the movements typically prescribed by therapists for the patients to do at home.

Other groups have used custom input, such as robotic arms and haptic devices [5,6,7,8]. While the input things do retrieve a lot of information, they are very costly, limiting the amount of people who can use them. In addition, the games designed were overly simplistic, and lacked motivating factors (such as fun!).

DESIGN GOALS

Our main goal was to have the games extremely customizable. Past studies mostly focused on a single movement, but to be adopted broadly, games must allow the therapist to choose the movements that the patient should perform. Some examples of movements our games support are elbow flexing, side to side arm movement, and rotation of the arm in the shoulder socket. We accomplished this customizability by using a variety of input devices to detect different sorts of movements, and creating games which mapped the real world movement to virtual movements.

Another goal was to make the games accessible to people recovering from strokes. By using cheap inputs, games that run on household computers, and settings that are quickly and easily configurable by the therapist, we lower the economic barrier to stroke therapy.

Finally, by making games fun and exciting, with sound effects and difficulty levels, we hope to take some of the tedium out of stroke recovery.

PROCCESS

Over a period of ten weeks, we developed several games taking different types of commercially available input. During that period, we met with four people recovering from strokes, a biomechanist, and an occupational

therapist. After each meeting, we would decide the elements of the games that had to be fixed. Since we coded in Java using the Alice graphics library, tailoring games was fairly simple.
By meeting with both an occupational therapist and a biomechanist, we were able to get different perspectives on stroke recovery. Occupational therapy typically is interested in helping patients resume activities of daily living (ADLs) while biomechanists are more interested in restoring previous levels of mobility. We made sure that our games were applicable to either goal, so therapists of any discipline could use the games.

INPUT DEVICES

For movements that involved bending the elbow, we used the Nintendo Wii remote. During our first session, our user did not have the hand flexibility necessary to grasp the Wii remote. Therefore, we created Velcro wristbands to strap onto the arms of our users. This allowed us to accommodate stroke patients who lack mobility in their hands. The Wii remote detects angles with respect to the downward gravitation vector, so it is not effective for side to side motion.

For side to side motion, we used a webcam. Our first use was simply tracking a colored ping pong ball through space. This allowed the user to move within a two dimensional field and see feedback on the screen. Our second use was to detect when the user was grasping an object and when s/he had set it down. This was done by placing a mitten on the user, and having them hold a different colored beanbag. The webcam detects colors, so we could judge whether the user was holding an object by how close together the two colors are.

GAMES

I developed two games over the ten weeks:
Under the Sea: This is a two person game played with Wii remotes. The scene is set with the camera positioned above the scene, looking down at the ocean floor. One player controls the fish, which swims about the left hand of the screen with babies trailing, collecting and eating ferns to get points. As soon as it eats a fern, a new one appears in a different location. Meanwhile, a hungry predator (Spiky) stalks the fish, coming from off screen to the right. If Spiky catches the fish, it loses one of its babies. Once it loses all its babies, five points are deducted. The other player controls the snail, which moves vertically across the right side of the screen to deter Spiky. Whenever it collides with Spiky, Spiky returns to its starting point off screen.

Garden: This game used webcam detection with a mitten and beanbag. The objective of this game is to clear the garden of weeds while preserving the flowers. The player sets down the dynamite stick (the beanbag) on a patch of weeds, and then pushes a handle to explode the dynamite. The dynamite decimates the nearest crop. Meanwhile, the plants continue to grow, requiring the player to lift higher, to avoid the flowers, when setting the dynamite on the weeds.

Other games included a baseball catching game, a variation of the classic Pong, and a driving game.

LESSONS LEARNED

Most of our users liked the games and said that they would definitely play the games at home. However, our initial versions had several problems, and our games went through many iterations.

- Our first user told us she wished she could play our games with her grandchild. We decided that playing with grandchildren would be an excellent motivator for people affected by stroke, most of whom are seniors. We designed several two player games. When testing out Pong with our second user, we realized that there was a problem with our scoring system, which deducted a point when a player missed the ball. The person with full limb functioning felt guilty scoring points against the opponent, for whom it was much more difficult to play the game. We eliminated the negative scoring, and began to

give points for longest rallies, thereby encouraging supportive playing.
We also added difficulty controls so the ball would travel slower when heading in the direction of the stroke patient. These controls relieved the frustration that had been experienced by the user.

- In one game, the goal is to 'catch' the cats that fall from the sky by flexing and unflexing the elbow, causing a ninja to move left and right across the bottom of the screen. Our second player had a great deal of trouble catching the cats. When we asked her why, she said she didn't understand how her moving up and down could cause a character to move left and right. When the third user had the same problem, we realized that by mapping up – down to left – right, we were adding a cognitive element that proved obstructive to the goal of movement therapy. We changed the input of Catch the Kitty to one which allowed left to right movement.

- Some users complained of the games getting boring after they played for a while. To make the games more motivating, we added several elements. To some games, we added automatic difficulty adjustment, where the game would increase in difficulty if a player was doing well. To other games, we added alternative elements, such as gold coins one could catch for bonus points. Another alternative element I added to my Under the Sea game was a set of ferns which would randomly appear. These ferns were worth more points, but had a countdown attached, so the player had to move fast to eat the fern before it disappeared.

- While watching the users, we noticed that many would arch their shoulders or shift their bodies to move the character on the screen instead of using the limb we had specified. To prevent this, we added compensation detection by strapping on a second Wii remote to an adjacent limb and calculating the angle between the two limbs. Now, when a patient shifted his/her body instead of lifting an arm, we could prevent the character from moving on the screen. This feedback forced the user to move the appropriate body parts to play the game.

CONCLUSION

We designed games that were easily configurable, cheap, and fun. Users enjoyed these games and authorities in the field of stroke found them useful.

More work could be done by testing the games on a wider range of users. In addition, it would be useful to have a study comparing traditional therapy to therapy in conjunction with our games.

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